

S P E C I F I C A T I O N

Docket No. 0438CG-54

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that we, Fred R. Huege, a resident of the state of Texas, and Starr Curtis, a resident of the state of Arizona, both citizens of the United States of America, have invented new and useful improvements in a

COMPOSITION FOR ASPHALT ROOFING MATERIALS

of which the following is a specification:

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Date of Deposit: 11-11-00

By: Christa King

1 BACKGROUND OF THE INVENTION

2
3 1. Field of the Invention:

4
5 This invention relates to asphaltic or bituminous
6 roofing materials and methods, and more particularly to
7 the manufacture of such roofing materials to which
8 hydrated lime ($\text{Ca}(\text{OH})_2$, abbreviated as "HL") is added to
9 improve the strength, durability and antioxidant
10 qualities of the roofing material. The roofing materials
11 may be shingles, rolls, or other materials to be placed
12 on roofs.

13
14
15 2. Description of the Prior Art:

16
17 Asphalt roofing shingles are manufactured by taking
18 a continuous base sheet of organic felt or fibreglass
19 (generally, a web or form), saturating it in a base
20 asphalt, covering it with a coating asphalt, and then
21 embedding granules on the top side of the coated sheet.
22 The granules protect the asphalt from breaking down
23 through oxidization by ultra violet rays. Fillers such as
24 CaCO_3 and/or fly ash may also be used in the asphalt
25 composition. Finally, synthetic polymeric materials may
26 also be added to the asphalt. The finished sheet is cut
27 into lanes and to a desired length of shingles.

28
29 More specifically, in the manufacture of roofing
30 shingles or rolls, a heated asphaltic/filler blend is
31 applied to a substrate web or substrate form, such as a
32 glass fiber mat or a felt. The mat or felt is pre-shaped

1 in the form that is desired for roofing purposes. After
2 the form or web is impregnated with the asphaltic mix, a
3 granular treatment may be applied to the hot asphalt
4 surface and rolled or pressed into place. The coated web
5 composition is then cooled so that it may be cut and
6 bundled as shingles, or formed into rolls.

7

8 The use of tar with HL to cover roofs is old in the
9 art, as disclosed in U.S. Pat. No. 61,787 (disclosing
10 first coating wooden shingles with HL, allowing it to
11 dry, then coating the shingles with the tar, followed by
12 sand). Asphaltic or bituminous materials as used in the
13 roofing industry for pre-fabricated shingles or asphalt
14 rolls are well known in the art, with the examples being
15 described in U.S. Pat. No. 4,405,680 (disclosing a
16 specific type of asphalt with glass filaments and method
17 of manufacture), and 4,559,267 (disclosing a sealant
18 bound to asphalt sheets). Prior to application to the
19 substrate or web form, the asphalt is typically heated in
20 an asphalt heater to a temperature of up to 500°F. The
21 heated asphalt is then blended with a filler that may or
22 may not be chemically inert, the filler also having been
23 preheated to a temperature necessary so as not to chill
24 the mix and to facilitate blending with the asphalt.

25

26 The choice filler has traditionally been based on
27 considerations of availability, compatibility and cost.
28 An inert filler material which has been preferred and
29 used by many roofing plants is powder limestone (CaCO_3)
30 or dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$), usually at a rate of about 40%
31 to 70% by weight of the mix. Other materials may also be

1 blended with the asphalt, such as block and anti-block
2 polymers and thinners, as well known in the art.

3

4 Powder limestone often has been a filler of choice
5 as it is widely available at a relatively low cost, and
6 is compatible with the asphalt mix. However, it is a
7 poor conductor of heat when compared to fly ash. It is
8 relatively slow to heat, and therefore, in the mix, tends
9 to insulate the asphalt and retards the cooling of the
10 composite web or form. Further, CaCO_3 is an active base
11 material, and it therefore tends to be acted upon by the
12 weak acid and the precipitation (acid rain) and is
13 believed to contribute to a shortened life of the roofing
14 material. More importantly, limestone fillers have been
15 documented as the cause of algae growth and discoloration
16 in asphaltic shingled roofs. This is somewhat
17 undesirable since it decreases the life of the shingles,
18 and also lowers the aesthetic quality of the shingles. In
19 this regard, MgCO_3 may be a better filler for asphalt.

20

21 In any case, it is desirable to have present in the
22 asphalt shingle a substance that can counter these and
23 other detrimental effects of filler agents or the asphalt
24 itself. At the same time, it is desirable to improve the
25 durability of roofing material and increase its tear
26 strength. While HL has been recently disclosed in use as
27 a filler in asphalt for paving roads (U.S. Ser. No.
28 09/110,410, filed on July 6, 1998), HL has not been used
29 in asphalt shingles or other roofing materials. Thus,
30 the present invention discloses a roofing composition
31 that is an improvement on the prior art that incorporates
32 the advantages of HL.

1 SUMMARY OF THE INVENTION

2
3 One object of the present invention is to provide an
4 improved roofing composition of shingles or asphalt roll
5 having a low cost additive that imparts improved tear
6 strength to the shingles, and is cost effective to use.
7

8 Another object of the present invention is to
9 provide an asphalt shingle of improved strength that can
10 be made with various types of asphalt.
11

12 These and other objects are achieved in an asphalt
13 roofing composition in the form of a roll or a shingle-
14 like structure in which a hot mixture of an asphaltic
15 base and filler is applied to a substrate form, wherein
16 the composition also comprises an amount of hydrated lime
17 (HL, such as any alkaline earth metal hydroxide) in order
18 to impart strength and durability to the composition.
19 The composition contains HL between about 1-10%, and
20 preferably between about 3-5%, of the asphalt by weight.
21 The filler can be fly ash, CaCO_3 , $\text{MgCO}_2 \cdot \text{CaCO}_3$, MgCO_3 , or
22 other suitable materials known in the art. In a typical
23 embodiment of the invention, the HL is added directly to
24 the asphaltic base of the composition either with the
25 filler, or with filler added after mixing the asphalt and
26 HL, or mixing the asphalt with the filler and then adding
27 the HL.
28

29 Additional objects, features and advantages will be
30 apparent in the written description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a graph of a SHRP parameter as a measure of permanent deformation potential for different asphalt binders with the addition of 20% HL by weight of asphalt binder;

Figure 2 is a graph of the change in viscosity of one HMA composition as a function of reaction time and blending time;

Figure 3 is a graph similar to **Figure 2**, but showing the results obtained with a second HMA composition;

Figure 4 is a graph of fracture toughness for one HMA composition with the addition of 20% by weight of HL;

Figure 5 is a graph similar to **Figure 4**, but with a second HMA composition;

Figure 6 is a graph of accumulated shear deformation for HMA mixes using two different bituminous binders;

Figure 7 is a graph of controlled-stain fatigue life comparing HMA's with and without the addition of HL;

Figure 8 is a top view of a typical asphalt shingle;

Figure 9 is a top view of a roof having asphalt roll material placed below a series of asphalt shingles; and

1 **Figure 10** is a graph of the tear strength of the
2 shingles of the invention when compared to traditional
3 (control) shingles.

CONFIDENTIAL

1 DETAILED DESCRIPTION OF THE INVENTION

2

3 The following abbreviations are used throughout

4 the specification: SHRP is Strategic Highway Research

5 Program; HL is hydrated lime ($\text{Ca}(\text{OH})_2$, $\text{Mg}(\text{OH})_2$ or

6 $\text{Ca}(\text{OH})_2 \cdot \text{Mg}(\text{OH})_2$); HMA is hot mix asphalt; and IDT is

7 Indirect Tensile. Other abbreviations are defined as

8 they are used.

9

10 The present invention is directed to improvements in

11 asphalt roofing materials and similar bituminous

12 compositions in which a lime component, preferably HL, is

13 added directly to the asphalt or asphalt in one

14 embodiment, or first to the filler and then to the

15 asphalt in another embodiment. In yet another

16 embodiment, the HL is added to the mixture of filler and

17 asphalt. Hereinafter, the terms "bitumen" and "asphalt"

18 are used interchangeably. Further, the term HL is used

19 to refer in general to any alkaline earth metal hydroxide

20 such as $\text{Mg}(\text{OH})_2$ and $\text{Ca}(\text{OH})_2$, or mineral mixture thereof

21 (generally, $\text{Ca}(\text{OH})_2 \cdot \text{Mg}(\text{OH})_2$). In the disclosure which

22 follows, the term "quicklime" refers to alkaline earth

23 metal oxides such as CaO , while the use of HL refers to

24 alkaline earth metal hydroxides such as $\text{Ca}(\text{OH})_2$.

25

26 In the production of HL, limestone or calcium

27 carbonate is first heated to remove carbon dioxide. The

28 remaining CaO is a very active chemical. To improve the

29 handling characteristics of the quicklime, a controlled

30 amount of water is added to form HL. Adding a HL

31 component to the aggregate or filler (e.g., rock, sand,

32 fly ash, limestone) in asphaltic compositions is done in

1 the present invention with the intention of improving the
2 bond between the aggregate/filler, fiber glass mat or
3 other substrate form, and asphalt, especially in the
4 presence of water which has a stronger affinity for the
5 aggregate than the asphalt does. This in turn improves
6 the tear strength of the shingle-like structure or
7 roofing material. Hydrated lime added to the aggregate
8 is an effective antistripping agent and has been
9 considered to have ancillary positive effects on the
10 asphalt mixture.

11
12 The mechanism by which HL improves aggregate-asphalt
13 adhesion and moisture sensitivity when the HL is added
14 directly to aggregate is reasonably well understood
15 although some arguments still exist as to the mechanisms
16 responsible. It is theorized that the lime decreases the
17 interfacial tension between the asphalt and water, thus
18 resulting in good adhesion. It is also thought that the
19 HL improves the stripping resistance by interacting with
20 the carboxylic acids in the asphalt. This interaction
21 forms insoluble products that are readily adsorbed onto
22 the surface of the aggregate or filler, or in the
23 specific case of roofing materials, the substrate form or
24 web used to make the shingle-like structures or rolls.
25 Some studies indicate that strong adsorption of calcium
26 onto mineral aggregate surfaces may contribute to bonding
27 of asphalt cements with the aggregate or filler.

28
29 The following data demonstrates that HL added
30 directly to asphalt has a multi-functional effect. The
31 effect which is achieved is more than simply that of an
32 antistrip additive. Hydrated lime was added directly to

1 five different asphalts (denoted AAB, AD, AAF, AAG and
2 AAM) which represent the range of asphalts that would
3 reasonably be encountered in the United States and
4 throughout most of the world, as discussed in Table 1.
5 Each of the selected asphalts represents a wide variety
6 of asphalt chemical and physical properties. The
7 research in the asphalt study concentrated on using
8 testing techniques that are now being accepted by the
9 industry as part of the Strategic Highway Research
10 Program's (SHRP) Superpave protocol. However, some non-
11 traditional tests were also performed. The testing
12 protocol is given below in Table 1. Although these data
13 apply to asphalt compositions for road use, they also
14 equally apply in general to the use of asphalt/HL
15 compositions in any conditions where there is exposure to
16 weather and physical stresses. These results, along with
17 those discussed in **Figure 10** below, show that the
18 asphaltic shingle composition of the present invention
19 has improved characteristics relative to typical asphalt
20 shingles, the HL having unexpected benefits.

21
22

Table 1. Tests performed upon various bituminous compositions.

Test	Parameters Measured	Purpose of Test
Series I - Investigation of low temperature performance IDT - Performed at three low temperatures for one hour to provide low temperature creep compliance on mixtures subject to aging (loose mix and compacted mix) according to Superpave protocol	Creep compliance versus time of loading - ultimate compliance, rate of change in compliance	Assess low temperature fracture properties (2 replicates for each mixture system - 18 samples)
IDT - Tensile strength at three low temperatures on mixtures subjected to aging as described above (AAMAS protocol)	Stress and strain at failure	Assess low temperature fracture properties (18 samples)
Series II - Investigation of intermediate temperature performance IDT - creep and tensile strength at intermediate temperature (20°C) to assess fracture properties (AAMAS protocol)	Creep compliance versus time of loading - ultimate compliance, rate of change in compliance	Assess intermediate temperature fracture fatigue properties (36 samples)
Series III - Investigation of moisture resistance Perform AASHTO T-283	Retained tensile strength	Assess effect of HL on moisture resistance (18 samples)
SERIES IV - Investigation of high temperature performance Compressive creep performed at 60°C one hour to assess permanent deformation potential (AAMAS protocol)	Creep compliance versus time of loading - ultimate compliance, rate of change in compliance	Assess effect of HL on high temperature rutting (6 samples)

1
2 The following summary of the experimental work is
3 divided into three sections: high temperature rheology,
4 low temperature rheology and intermediate temperature
5 rheology. At high temperatures, asphalt becomes soft and
6 susceptible to shoving and rutting when used in roadways,
7 and creeping or deformation when used as roofing
8 materials. The tests performed evaluated the ability of
9 the asphalt to withstand the stresses induced in high
10 temperature environments. At low temperatures, asphalt
11 becomes hard and susceptible to fracture. This is
12 particularly true for asphalt mixtures that have become
13 embrittled due to aging. The tests performed at low
14 temperatures evaluate the ability of the asphalt to
15 withstand load-induced and environmentally induced
16 stresses at low temperatures. Load-induced fatigue
17 cracking typically occurs at low and intermediate
18 temperatures. The test performed at intermediate or
19 average temperatures assess the ability of the asphalt to
20 withstand fatigue at average or nominal temperatures. The
21 tests were conducted by reacting the asphalts in mass
22 with the HL in closed containers in accordance with the
23 previously enunciated testing protocols.

24
25 **Evaluation of the Effects of HL on High Temperature**
26 **Rheology.** Hydrated lime added directly to the asphalt in
27 selected ranges from about 10% to about 20% by weight,
28 based on the total weight of asphalt binder produces
29 several high temperature rheology effects which can be
30 summarized as follows:

31

1 Hydrated lime added to asphalts has a very positive
2 filler effect. This effect substantially improves high
3 temperature rheological parameters which relate to
4 resistance to permanent deformation. Figure 1 shows how
5 20% HL by weight asphalt binder dramatically changes the
6 SHRP parameter $G^*/\sin \delta$ which is related to permanent
7 deformation potential. A high $G^*/\sin \delta$ results in
8 reduced permanent deformation potential. Somewhere
9 between 10% and 20% HL by weight asphalt binder is
10 required to provide the desired high temperature
11 rheological changes. In the HL containing shingles, only
12 about 1 to 10% HL by total weight of asphaltic/filler
13 composition is required to effectuate an improvement in
14 tear strength and antioxidant properties.

15
16 The high temperature rheology of HL-filled asphalts
17 is dependent on the time and temperature of blending of
18 HL with the asphalt. The process is asphalt specific.
19 This finding demonstrates that the interaction between HL
20 and asphalt is likely not simply physical but a chemical
21 interaction may also exist.

22
23 Figures 2 and 3 illustrate the effect of reaction
24 time at 149°C on HL in asphalt AAD to reaction time of
25 longer than five minutes. However, asphalt AAM requires
26 a reaction time of about 40 minutes to achieve viscosity
27 equilibrium. This indicates a physio-chemical
28 interaction unique to specific binders. Note that the
29 untreated asphalts are unaffected by reaction time.
30 Since the asphalts were reacted in mass in closed
31 containers, oxidative aging should not be a factor.
32 However, the HL, when added to the asphalt in roofing

1 The improved low temperature properties are due to
2 a synergistic effect of reduction in the effect of
3 oxidative aging (as all samples are aged to simulate
4 pavement aging before testing) and crack pinning, a
5 phenomenon of energy dissipation due to microcrack
6 interception by the dispersion of HL particles in the
7 asphalt.

8

9 **Evaluation of Effects of HL on Intermediate Temperature**
10 **Rheology.** The filler effect of HL is obvious at all
11 temperatures. However, at low temperatures the
12 stiffening effect was proven to be more than compensated
13 for by the improvement in fracture toughness. No
14 generally recognized accepted binder tests are available
15 by which to evaluate intermediate temperature fatigue
16 susceptibility. Therefore, the following mixture tests
17 used: direct tensile fatigue tests and microcrack
18 healing tests. These tests provided favorable results
19 which are discussed in the mixture section.

20

21 **HL in Asphalt -- Effects on Mixture Properties.** Hydrated
22 lime was added to two asphalts with very different
23 chemical and physical properties. These asphalts are
24 designated AAD and AAM. Mixtures with Watsonville
25 granite aggregate and 5.05% asphalt by total weight of
26 the mixture were subject to two types of mixture tests:
27 repeated shear permanent deformation testing and direct
28 tensile fatigue testing. The repeated stress, permanent
29 deformation testing was performed to assess rutting
30 potential in the mixtures tested. The direct tensile
31 fatigue testing was performed to assess the effect of
32 lime on the potential of the mixture to develop fatigue

1 cracking. These are two of the dominant distress
2 mechanisms in hot mix asphalt pavements and are
3 responsible for the vast majority of pavement damage and
4 deterioration.

5
6 **Results of Permanent Deformation Testing.** The repeated
7 shear permanent deformation testing was performed at
8 40°C. The testing was performed using a testing protocol
9 developed in the SHRP research program to simulate the
10 stress state that an asphalt mixture is subjected to
11 under a moving wheel load. During the testing sequence
12 the mixture is subjected to a constant ratio of axial
13 stress and repeated shearing stresses.

14
15 Tests were performed on HMA mixtures prepared with
16 four different asphalt binders with and without HL as
17 follows: AAD, AAD 12.5% HL, AAM and AAM with 12.5% HL.
18 Three identical samples were prepared for each mixture
19 and the mixtures were subjected to a 20,000 lbs. load
20 application. The tests revealed that the addition of HL
21 reduced the level of permanent deformation on average
22 about 300% (**Figure 6**), based on values of ultimate
23 permanent strain after 20,000 cycles. The data were
24 considerably variable, however. Although the above tests
25 were performed on mixtures of asphalt and granite
26 aggregate, the same or similar results are expected with
27 glass filaments and/or fly ash, or the substrate forms
28 used to make the shingles or roofing rolls of the
29 invention, as they have the common property of being
30 siliceous and/or carbonaceous.

31

1 **Results of Direct Tensile Fatigue Testing.** The purpose
2 of direct tensile fatigue testing was to assess the
3 resistance of asphalt mixtures to load-induced
4 (controlled-strain) fatigue testing at intermediate (or
5 average annual) pavement and exterior temperatures that
6 shingles will be exposed to. Identical mixtures of
7 Watsonville granite and 5.0% asphalt (by total weight of
8 the mixture) were prepared with asphalt binders with and
9 without HL as follows: AAD, AAD with 12.0% HL, AAM and
10 AAM with 12.5% HL. Analysis of the results of
11 controlled-strain fatigue testing demonstrated two
12 findings. First, at a given level of stiffness, the
13 addition of HL improved fatigue life. Second, the
14 recovery of dissipated energy (responsible for crack
15 healing) after rest periods is enhanced by the addition
16 of HL for mixtures subject to age hardening. For a given
17 design stiffness and for a mixtures subject to age
18 hardening, the addition of HL appears to enhance the
19 resistance to fatigue cracking.

20
21 **Figure 7** illustrates typical fatigue results where
22 cycles to failure (Nf) are compared for untreated and HL
23 treated mixtures at various mixture stiffness.

24
25 An invention has been shown with several advantages.
26 HL is an effective multi-functional additive which is
27 effective in improving the high temperature performance
28 of hot mix asphalt.

29
30 Uniaxial tensile controlled strain fatigue tests,
31 performed on mixtures with and without the addition of HL
32 added directly to the binder, demonstrate that the lime

1 addition improves the fatigue life of the mixture
2 (resistance to cracking) when mixtures are compared at a
3 common level of stiffness.

4
5 Shingles, shingle-like structures which come in
6 various forms, or asphalt rolls used for roofing
7 typically are made from glass impregnated mats or
8 substrate forms, the asphalt and fillers, etc. being
9 bound and formed around the mat or form. The shingles
10 can be as shown in Figure 8, wherein asphalt shingle 10
11 having an adhesive strip 12 is shown. A number of
12 shingles 10 are placed upon a roof 16 as in Figure 9,
13 wherein sheet material from a roll of asphalt material 14
14 is first placed on the roof underneath the layered
15 shingles 10. The roll comprises a rolled sheet of
16 asphaltic material, usually formed around a substrate web
17 or form, the layer of material placed directly in contact
18 with the wood roofing material prior to addition of the
19 shingles as in Figure 8. Further, various polymers can
20 be added to the asphalt along with the HL of the
21 invention, such as disclosed in U.S. Pat. No. 4,405,680.

22
23 Typical fillers for the composition include
24 limestone and/or dolomite dust and glass fibers of
25 various sizes and lengths, sand, rock (of various mineral
26 composition), and other substantially siliceous materials
27 in ground and/or powdered form. The asphalt utilized in
28 the asphalt composition of the present invention is
29 typical of the industry. An asphalt of this type
30 typically has a softening point of between, for example,
31 190°F and 240°F and a penetration at 77°F between, for
32 example, 14 dmm and 25 dmm (dmm is tenths of a

1 millimeter). In saturating the substrate form, the
2 asphalt is maintained in a molten state, preferably at a
3 temperature any where between 350°F and 450°F. At this
4 temperature and without any fillers or additives, the
5 molten asphalt has a viscosity and Saybolt furol seconds
6 of 100 and 300.

7
8 The physical properties of the asphalt, as recited
9 herein, are for exemplary purposes only. Any asphalt
10 which functions in the manner to be described herein may
11 be utilized, and in fact, may be readily provided by
12 those skilled in the art. In this regard, the saturating
13 or coating temperature of the molten asphalt, or the
14 operating temperature as it is commonly called, will
15 depend in part on the particular asphalt used and in part
16 on other ingredients in the overall composition. In any
17 event, the temperature of the asphalt should be
18 sufficiently high to readily saturate or coat the
19 substrate form with the asphalt composition, yet it
20 should not be maintained at a temperature higher than
21 necessary. This is, of course, because a large amount of
22 energy is required to maintain the composition in its
23 molten state.

24
25 The asphalt composition of the present invention
26 preferably includes between about 30% and 50% asphalt by
27 weight of the total composition. When less than
28 approximately 30% is provided, the asphalt does not
29 satisfactorily fulfill its intended purpose, that is, it
30 does not satisfactorily provide the ultimately produced
31 shingle or roll with adequate physical characteristics.
32 In addition, it tends to be too viscous at the preferred

1 saturating temperatures and thus increases creep. On the
2 other hand, providing the composition with more than 50%
3 asphalt is not necessary and, taking into account costs
4 considerations, is not preferable. In this regard, to
5 extend the asphalt, a suitable conventional filler, such
6 as for example, limestone and other mineral filler is
7 added thereto.

8
9 The mineral filler is dispersed throughout the
10 asphalt by conventional means. For example, mechanical
11 agitation, when the asphalt is in its molten state,
12 preferably at this saturating temperature. Between
13 approximately 45% and 55% mineral filler, by way of the
14 total composition, is preferably utilized. The exact
15 percentage of mineral filler provided will be dictated by
16 the amount of asphalt and the amount of glass in the form
17 of glass fiber bundles which are utilized in the
18 composition, especially when these are the only
19 ingredients comprising the composition. Of course, the
20 filler must not be of a type or an amount which will
21 prevent saturation of the base sheet at any reasonable
22 saturating temperature.

23
24 There are several principle methods of mixing the
25 composition of the invention. The first is to add the HL
26 to the molten asphalt. The second is to add the HL to
27 the filler first, mixing or agitating it thoroughly
28 first, with or without excess water, then adding the
29 molten asphalt. A third method is to first mix the
30 asphalt and filler, then add the HL to the mixture. In
31 either case, the HL is added to between 1% and 10% of the
32 added asphalt. Preferably, the HL is added to an amount

1 between 3% and 5% of the weight of the asphalt. Hydrated
2 lime is added as a powder. The asphalt/HL and/or
3 filler/HL mixtures are typically agitated to achieve an
4 uniform distribution of the lime. This can be done with
5 a pug mill, however, in some cases vigorous mixing is not
6 necessary.

7
8 In one embodiment, the HL is added directly to the
9 filler first as a dry powder, both ground and mixed to
10 form a homogeneous mixture. The HL can be added prior to
11 or after grinding the filler material. In yet another
12 embodiment, CaO (or $\text{CaO} \cdot \text{MgO}$) is added to wet or damp
13 rock, thus being hydrated in a reaction between the CaO
14 and H_2O to form $\text{Ca}(\text{OH})_2$ (or $\text{Ca}(\text{OH})_2 \cdot \text{Mg}(\text{OH})_2$). The reaction
15 mixture is then ground to the desired particle size. In
16 yet another embodiment, CaO (or $\text{CaO} \cdot \text{MgO}$) or HL slurry is
17 added to the rock prior to grinding to the desired
18 particle size.

19
20 The HL can also be mixed with the asphalt as the
21 asphalt is heated to make the mixing easier. The
22 temperature is dependent upon the type of asphalt, as
23 discussed above, and its viscosity.

24
25 As stated above, in accordance with the present
26 invention, a small percentage of glass in the form of
27 glass fiber bundles is added to the asphalt filler
28 mixture. These glass fiber bundles are dispersed
29 throughout this mixture and could be dispersed throughout
30 the asphalt prior to the addition of the filler but in
31 any case, are added while the asphalt is in its molten
32 state, preferably at its saturating temperature. In this

1 regard, the glass may be dispersed in the asphalt by, for
2 example, mechanical agitation.

3

4 As stated previously, the asphalt-filler mixture,
5 when maintained at the saturating temperature between
6 350°F and 450°F, will have a sufficiently low viscosity
7 so as to permit easy saturation of the base sheet. While
8 the addition of the glass fiber bundles to this mixture
9 will increase the viscosity slightly, the amount and type
10 of bundle selected must be such that the overall
11 composition at the saturating temperature has a
12 sufficiently viscosity level to permit easy saturation of
13 the base sheet.

14

15 The exact type of glass fiber mat which could be
16 used may vary and could also be readily determined by
17 those skilled in the art in view of the teaching of the
18 present invention. However, those which have been found
19 to be acceptable are between approximately $\frac{1}{8}$ and $\frac{1}{2}$ in
20 length, including between 100 and 800 per bundle and
21 having a filament diameter of, for example, 13 to 18
22 micrometers. The binder utilized in holder the micro
23 filaments together must be, of course, one of which will
24 continue to hold the bundles together, to at least to a
25 substantial degree, and the saturating temperature of the
26 asphalt, even though the asphalt is mildly agitated to
27 disperse the glass bundles. It must also be one which by
28 melting, dissolving or any other way, allows the fiber
29 bundles to defilamentize to a large extent at
30 substantially higher asphalt temperatures, for example,
31 at temperatures in excess of 700°F. Limestone (CaCO_3),

1 sand, fly ash, and other siliceous materials are typical
2 binders used each alone or in some combination.

3

4 In one embodiment of the present invention, the
5 shingles are manufactured by first providing a fiberglass
6 mat of a preformed shape and size. Hot asphalt having
7 the filler and HL is then applied to the top of the mat
8 to the desired thickness. The asphalt is then allowed to
9 dry. Next, the uncoated side of the mat is exposed, and
10 hot asphalt is then applied to the uncoated surface to
11 the desired thickness. This is then allowed to dry. In
12 a finished product, sand or other decorative material may
13 be added to the surface prior to drying to adhere the
14 sand or other material the surface of the shingle.

15

16 The shingles of the present invention have the
17 unexpected advantage of having a greater tear strength
18 than traditional asphalt shingles not using HL. The data
19 in **Figure 10** highlight this aspect of the present
20 invention, wherein control samples (filled circles) of
21 shingles that do not have HL were compared with the HL
22 containing shingles (closed squares) of the present
23 invention. Shingles of various thickness (in fractions
24 of an inch) were compared and the tear strength of each
25 compared to one another. The data for the HL shingles
26 use a composition of 3% HL by weight of asphalt. The
27 line 101 is a best-fit line through the data for the HL
28 shingles of the invention, while the line 103 is the
29 best-fit line through the data for the control.

30

31 The increased tear strength of the HL shingles of
32 the present invention is an advantage over prior

